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EXPERIMENT STATION

BOTANICAL DEPARTMENT

MICHIGAN POTATO DISEASES

BY

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This bulletin contains a description of the serious diseases which cause a shortage in the potato crop of Michigan. There is also given a definite program for handling the crop so that this great leak in our agriculture can be stopped. The control of potato diseases means millions for Michigan.

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INTRODUCTION.

THE PLAN OF THE BULLETIN.

The bulletin is a brief handbook of potato diseases. The diseases are arranged according to methods of control employed and the salient facts about each disease are given in connection with an illustration which shows the characteristic signs by which the disease may be recognized. The causal agent, when known, is discussed and its life history told. Methods of control based upon life history of the parasite are then given. These control measures are general and outline the principle involved in the treatment. A definite program recommended for potato growers is given on the last pages of the bulletin. Here also the making of Bordeaux Mixture is outlined.

THE CAUSES OF PLANT DISEASES.

By "plant disease" we mean for plants the same sort of thing as is meant by the term "animal disease." A plant which departs from the normal or average course and fails to make suitable growth or yield proper returns, is, in the broadest sense of the term, "diseased." Farmers know very well the types of disorder which come from weather or soil conditions. They understand the effects of insect pests. They are less familiar with the disorders which arise from the attacks of plant parasites. The plant parasites which attack our crops are either *fungi* or *bacteria*. A parasitic fungus is a microscopic plant which makes no food for itself, but which steals its living from another plant. The body of the fungus consists of threads which grow in or upon the sick plant which is thus used as the source of food. Fungi are spread by spores—small bodies which are the "seeds" of the parasite. They are produced in countless numbers and are small and light enough to be blown about by small currents of air or by the wind, or else they are splashed about by rains, etc.

Other diseases are caused by bacteria—minute rod-shaped plants that consist of a single cell. These cells are commonly motile and swim about in water by means of minute whip-like outgrowths. Bacteria are remarkable in the rapidity of their growth and multiplication. Under favorable conditions, they merely elongate and cut in two, and hence from one organism in the course of an hour or less, two arise. Each of these in turn produces two more, and so in the course of a day countless numbers arise from the one germ.

Other diseases seem of a degenerative nature, the true cause of which is unknown. The farmer must clearly realize that seed tubers grown on well fertilized soil are less liable to certain diseases than those grown on weak, impoverished soil.

THE PRINCIPLES OF DISEASE CONTROL.

The farmer can fight plant diseases intelligently only by knowledge of the life story of the parasite, its mode of life, its method of injury, and its ways of spreading. The methods of plant disease control in general fall into three groups:

1. Sanitary and hygienic measures.
2. Plant protection measures.
3. The use of resistant varieties or strains.

The first of these means clean seed in clean soil, or better, *safe* seed in *safe* soil. It is probably the most important of all disease control measures and the one most easily practiced.

The second has to do with actual treatment of plants, spraying with fungicides, in order to protect them from fungous invaders. Spraying when properly done is highly profitable.

In the third method of plant disease control lies the hope of the future. Under this head are included disease-tolerant and disease-escaping forms, and varieties and strains which, due to some inherent protoplasmic quality, resist parasitic attack. The discovery or the development of such strains alone will emancipate us from the enormous toll which parasites levy. While some disease-resistant strains exist, long research and trial yet remain before the ideal disease-resistant potato plant is produced. Scientific investigation alone can solve this problem for agriculture.

DISEASES CONTROLLED BY SPRAYING WITH BORDEAUX MIXTURE.

LATE BLIGHT OF THE TOPS; ROT OF THE TUBERS.

Economic importance:

This is the worst disease of the potato and probably the most destructive of all plant diseases. Periodically great epidemics of this disease sweep the great potato-producing states, destroying from a quarter to one-half of the total potato crop of the nation. The disease cost Michigan, according to conservative estimate, $2,000,000 in 1912, and $4,000,000 in 1915. A repetition of this waste would be a national calamity.

Signs—On leafy parts:

Blighting begins at tips or edges of leaflets and makes dark, greasy or watersoaked spots, usually involving one-third to one-half of the leaflet when first noticed. The under surface of a leaflet so affected appears filmy or cobwebby with the fruiting threads of the fungus. (Fig. 1.) Under wet

Fig. 1. Underside of leaf showing spots caused by Late Blight. Note whitish, fungous outgrowths.

conditions, all tender parts of the tops blight and quickly rot away, with a characteristic, rank odor. A blighted field looks as if struck by frost.

On the tubers:

At the first stages of rotting, the affected tubers show slightly sunken, lead-colored or pinkish areas. (Fig. 2.) Sometimes these are mere depressions here or there, making the tuber look hob-nailed. Under moist conditions in storage or when dug from wet fields, the potatoes may show grayish-white tufts of the fungus. These are fruiting threads such as have been mentioned before as occurring upon the leaves. Such rotting is worst on tubers grown on heavy soil.

Fig. 2. Tubers affected with Late Blight.

The flesh beneath the sunken skin is brown. (Fig. 3.) When the skin is scratched away the tell-tale brown discoloration of the flesh indicates the blighted condition of the tuber which makes it unsafe to ship or store. As the blight advances in the tuber, more and more of the flesh is involved and the color of the rotted flesh changes to black. If the storage conditions are dry, the tuber wizens into a mummy—"Dry Rot." If the tubers are kept wet, or even moist, as in the car, they rot with an ill-smelling, slimy rot, "Wet Rot."

The cause:

A parasitic fungus, *Phytophthora infestans* (Mont.) de Bary, which is restricted in its attack to the plants of the potato family, causes this disease.

The life history of the causal organism:

The fungus is probably carried to the field as a lurking infection in practically every lot of tubers planted. No experiments have been able to demonstrate that the fungus lives over winter from crop to crop in the soil. The majority of sprouts which arise from infected seed tubers are weak and subject to rotting in the ground, thus giving a poor stand. However, under favorable weather conditions a few infected sprouts get above the ground and communicate the disease to nearby plants. Given favorable weather

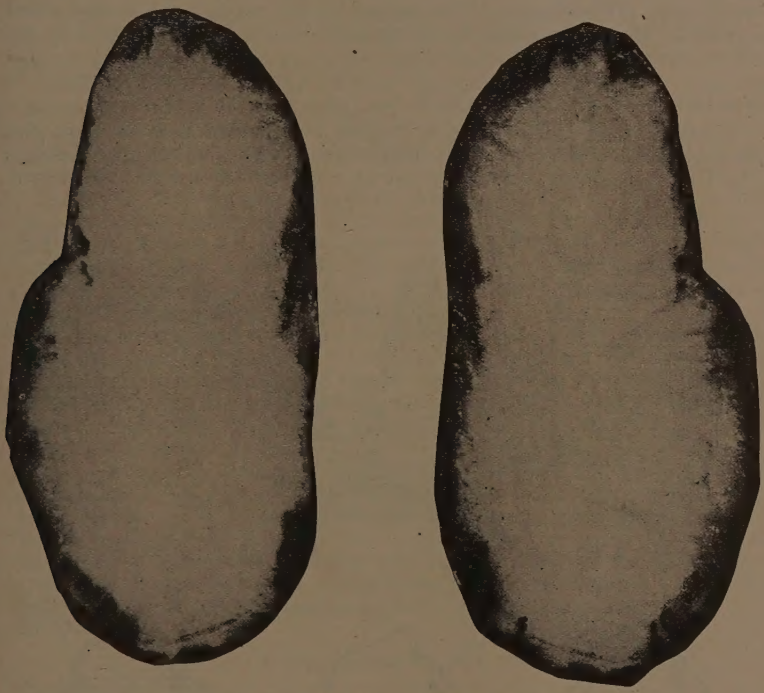


Fig. 3. The effect of Late Blight on the flesh of the potato tuber.

conditions to promote spread and growth of the spores of the fungus in the first half of the growing season, the disease spreads from plant to plant and becomes established throughout the field. With such an entrenchment of the fungus in the field, even moderately wet weather the last half of the season is sufficient to bring about a blight epidemic. To the farmer, the blight seems very sudden in its action, but in reality the fungus has been establishing itself for more than a month.

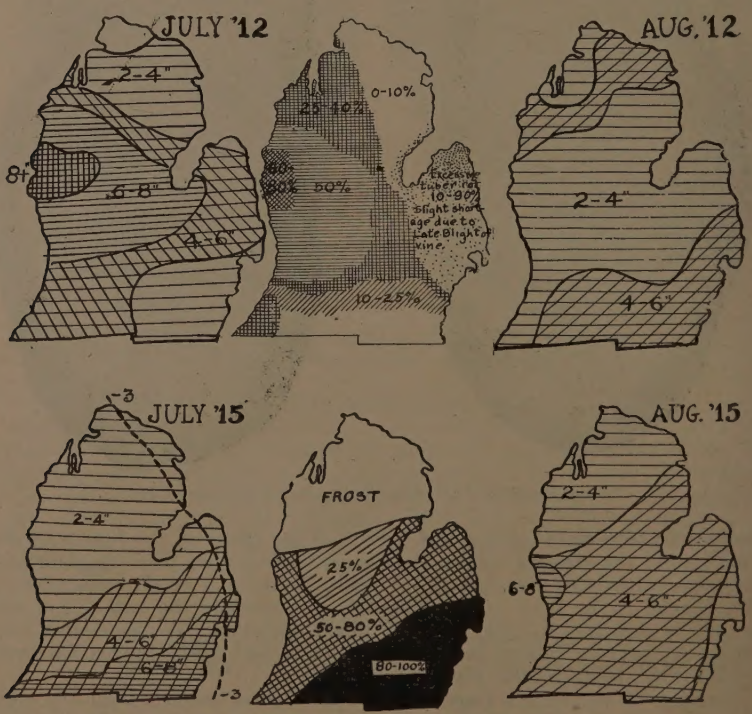
Rotting of the tubers comes about from spores washed from the tops through the soil, or shaken upon the tubers at digging time. It does not come about from the fungus working down the stalk as is generally sup-

posed. An examination of the blighted areas on the tuber will show this beyond question. Occasionally the fungous spores wash down along the stem and cause a rotting, in close-setting varieties, which begins at the stem end of the tuber.

A spore of this parasitic fungus, carried to the tuber, sprouts, if given favorable conditions of moisture and temperature, and bores through the skin. Once the fungus gets into the flesh of the tuber the advance is rapid. The browning of the flesh is an indication of the activity of the parasite. The rapidity of the progress of the rot depends upon the temperature of the storage cellar. Temperatures near the freezing point check the growth of the fungus. The advance of the fungus is very rapid if the storage cellar is warm. Moist conditions favor spore production and the spread of the rot in storage.

Weather relations:

A cool, wet July followed by an August with moderate or heavy rainfall always has given epidemics of Late Blight in the Lower Peninsula of Michigan. The Upper Peninsula, commonly having cool, wet seasons, has blight more



Figs. 4 and 5. The rainfall (in inches) of July and August for 1912 and 1915 respectively, compared with the prevalence of Late Blight. (Center map.) Note that the rainfall of July was decisive in determining areas of greatest loss.

frequently. The reason for this weather relation has already been explained. Some of the observations on which this statement of weather relations is based are given in the diagrams. (Figs. 4 and 5.) From these observations we may predict with considerable accuracy the years in which Late Blight is going to damage the crop. While we advise spraying every year as a good business policy, this method of prediction enables the College to warn the farmers as to when an epidemic is threatening. It behooves a farmer to be prepared with spray machine and copper sulphate if he is to take advantage of the danger signal and save his crop.

Control measures:

Probably no commercial seed stock available to the farmer is truly "blight-free," although some are advertised as such. Moreover, no practical method has been devised of ridding seed of blight infestation.

Tubers showing even slight evidence of rot should be sorted out, not that this sorting will eliminate blight, but because sprouts from such potatoes are notorious in giving a poor stand of weakly hills. Sound tubers from a stock which has rotted from Late Blight are safe to plant, but the rotted tubers are dangerous.

The main control measure against Late Blight, as well as other foliage diseases of the potato, consists of the thorough application of properly made Bordeaux Mixture. Spray the plants every 10 days or two weeks, beginning when the tops are 8 to 10 inches high. If you can raise 150 bushels or better, spray every year. Everyone should spray when the first half of the growing season (July) is cold and wet.

If protective sprays have been neglected, a crop can still be saved if the blight is recognized when first starting. When the tops are blackened and the foliage wilted, nothing can be accomplished by spraying.

Spraying seeks to prevent wholesale leaf infection. It prevents rotting of the tubers since it does away with the source of tuber infection, namely the diseased leaves.

In preparing for shipment or storage, sort out all tubers showing any signs whatsoever of blight. Such tubers are a sure source of loss. They are diseased in the field and they never improve. Some buyers will not handle potatoes from districts where blighting has occurred. Close sorting, frequently repeated, with cool, dry, well-ventilated storage minimizes loss.

The great economic waste which arises from Late Blight is unnecessary and would be avoided if farmers adopted a rational spraying practice.

EARLY BLIGHT OF THE TOPS.

Economic importance:

This disease causes loss because it prevents a crop of potatoes from becoming the maximum the soil is capable of returning. In years when Early Blight is prevalent the disease may reduce yields as much as 25 per cent. Late Blight destroys a crop of tubers already produced, while Early Blight cuts down the possible size of the crop. This disease and Tip Burn are largely responsible for the mediocre yields which come from seemingly well cared for fields. In years when Late Blight is not present to injure the crop, these two troubles take a heavy toll.

Signs—On the leaflets:

Small (one-eighth to one-fourth inch in diameter), black spots are produced on the leaflets. (Fig. 6.) These spots are more or less circular, except where two or more spots run together. Each spot represents a point of attack of the parasite and marks the place where a spore germinated and

Fig. 6. Early Blight on the leaves.

entered the leaf. As the fungus grows in the tissue, the cells of the leaf die and turn black. The drying effect of the fungus upon the leaf tissue is represented by lines forming concentric rings about the spot. The "target-board markings" are a means of determining the disease.

On the tubers:

No direct rotting or marking is produced upon the tubers by this disease. The tubers produced on diseased plants are smaller since the yield is reduced on account of the weakened leaves.

The cause of the disease:

A parasitic fungus, *Alternaria solani* (E. and M.) J. and G., known to attack potatoes and tomatoes and possibly other solanaceous plants is the cause of this disease.

The life history of the causal organism:

The fungus which causes this disease probably lives over winter on trash, etc., in the soil. It is probably widespread in every field where potatoes are grown and must be recognized as a pest sure to be met with if the season permits. Spores from the trash finding a place on the leaves of the potato, germinate under wet conditions and cause the characteristic spots of the disease. On the diseased spot the fungus fruits profusely, producing the characteristic club-shaped spores of the fungus. These spores in turn are carried to fresh leaflets chiefly by wind and rain and thus from a few spots, countless points of infection result. This story is repeated over and over in the field so long as the weather relations favor infection. A spotted leaflet is weakened and sometimes turns yellow and dies.

The leaves of the potato are the manufacturing organs which make the starch which is stored in the tubers. Anything which interferes with the efficiency of these food-producing organs cuts down the yield of tubers.

The relation to the weather:

The disease, while present in more or less abundance each year in Michigan, is most severe in years when the season is warm and with moderate rainfall.

Control:

The system of summer spraying outlined under the Late Blight of potatoes controls this disease and a consistent spraying program is recommended for use with every high-yielding potato crop.

TIP BURN.

Economic importance:

This trouble is the cause of the wholesale "blighting" and drying up of the leaves of potatoes during hot, dry seasons. It is important to the farmer since it affects yields the same as Early Blight.

Cause:

This disease is not due to a parasite, but results from the parching of the leaves under the influence of hot sun and drying winds. It is especially severe when a period of cool, wet weather is followed by hot, dry conditions.

Signs:

The leaflets die at the tips and edges. (Fig. 7.) Injured leaflets curl slightly. Eventually the whole top withers away as a result of the severe effect upon the leaf surface.

The only effect on the tubers is the secondary effect which comes from injured leaves.

Control:

Although this disease is not caused by a parasite, Tip Burn is greatly lessened and sometimes entirely prevented by the application of Bordeaux Mixture. Sprayed fields remain green, unsprayed fields burn and blight. That this condition is brought about by actual stimulation of the potato plant by the copper of the Bordeaux spray has often been surmised. There seems, however, to be good reason for believing that in some way, the copper of the Bordeaux keeps the chlorophyll (green coloring matter of the leaf, which in sunlight manufactures the starch) in good working order—preserves it, so to speak.

Fig. 7. Tip Burn.

The results of controlling Tip Burn are clearly seen in the increased yields from sprayed over unsprayed fields. Even in years when Late Blight is not present, the gain in yield from potatoes grown on fertile and properly cultivated soil can be safely placed at from 15 to 25 bushels per acre. Besides this gain which comes year in and year out, the farmer has the assurance that Late Blight will not ruin his crop. Spraying is a form of crop insurance whose premiums are all dividends.

ARSENICAL INJURY.—TOO MUCH, OR IMPROPERLY APPLIED PARIS GREEN, ARSENATE OF LEAD, ETC.

The signs:

Dead spots frequently appear on the leaves, usually starting from wounds (insect injuries.) (Fig. 8.) These spots greatly resemble Early Blight. Residue from heavy dosage with Paris Green or Lead Arsenate is present on leaves and stalks.

Frequently dead tips of growing shoots are to be found associated with heavy accumulation of poison at the leaf axils.

Dead areas may occur on exposed stems, the dead surface showing a metallic luster.

Fig. 8. Arsenical injury. The holes in the leaves were made by Flea Beetle.

DISEASES CONTROLLED BY THE TREATMENT OF SEED TUBERS.

POTATO SCAB.

Economic importance:

This disease each year causes enormous losses which are in general overlooked. In many fields, five per cent of the tubers are too scabby to be picked up at all; five per cent or more may be rejected at the car door. A noticeable amount of scab makes potatoes unfit for marketing under the new government grades. At the great markets ungraded potatoes are

Fig. 9. Potato Scab.

sorted again before bagging. Here five per cent more become culls. The farmer may not know that he is standing this loss, but it is reflected in the price paid him for the low-grade product. It is safe to say that the Michigan crop shrinks from 10 to 15 per cent, year in and year out, because of Scab.

Scabby seed gives a poor stand and a poor crop of scabby, and in part, at least, of deformed, small tubers.

Signs of the disease:

These are well shown by the illustration. (Fig. 9.) Often the individual scab spots merge, making the entire potato roughened and worthless.*

Cause:

One of the higher bacteria, *Actinomyces chromogenus* Gasperini, is the cause of this disease. This organism was formerly classified as a low form of fungus and under the name *Oospora scabies* Thaxter.

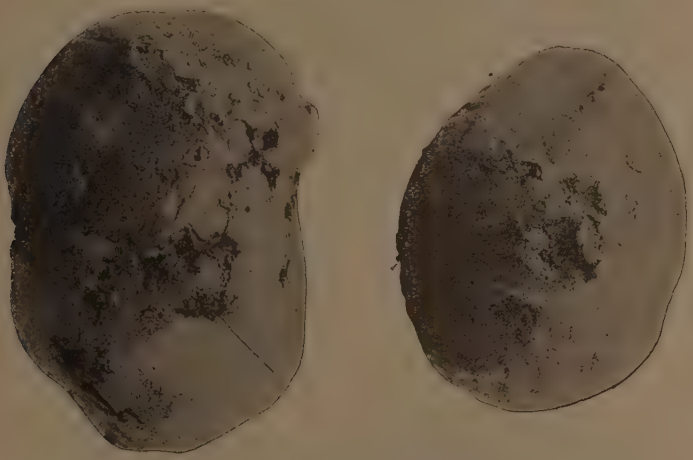


Fig. 10. Deep Scab caused by Soil Mites.

Life history of the causal organism:

In spite of the many theories as to the origin of Potato Scab, it is now generally recognized that a specific parasite is responsible for the disease. The organism belongs to a group that is common in all soils, especially those in which plenty of organic matter is decaying. It is likely a wide range of plants is attacked by the same organism, but so far, the disease is only recognized upon the sugar beet and the potato.

Scab spots harbor the bacteria. These germs may be seen at digging time as a white or grayish film on moist scab spots. This film consists of threads of the bacteria which break up into small parts, each of which is capable of starting a growth of the organism, (called a colony.)

While organisms much like the scab organism may exist naturally in our soils, the organisms which come from the scabby tubers seem to be the virulent ones and are the greatest source of danger to the next crop. When a scabby tuber is planted this furnishes the chief source of virulently infectious material for the new tubers. It is, of course, evident that the germs may drop from the scabby tubers upon sound tubers, hence apparently clean tubers may carry the germs to the field. Clean or disinfected tubers put in old potato sacks or crates may become contaminated with germs.

*Frequently Deep Scab occurs. This is the work of soil mites which may attack at a scab spot or directly through the tender skin of the tuber. (Fig. 10).

The organism causing this disease thrives best under alkaline soil conditions, rather than under acid soil reaction.

Control:

The following specific directions for control may be given:

Rotate the potato crop as a sanitary measure to prevent the soil from becoming heavily infested with the virulent strains of the scab germ.

Utilize the more acid soils for potatoes.

Heavy liming of the soil seems to increase the amount of Scab. Lime should follow the potato crop rather than precede it.

Scabby tubers are culls and should be sorted out. Plant only smooth, sound seed-stock. Cook the culls for stock food. When corn is worth $1.60 a bushel, potatoes are worth $0.40 for feed purposes.

Disinfect all tubers planted as directed under "Seed Treatment" on page 43.

THE RHIZOCTONIA DISEASE, "BLACK SCURF," (ALSO CALLED LITTLE POTATO AND ROSETTE.)

Economic importance:

This is a very serious disease on poorly drained or "crusty" soils. It is the frequent cause of poor stands, especially in wet years and in the wet portions of fields. In its effects on the tubers it is more or less disfiguring, since tubers showing "Black Scurf" are not first class stock.

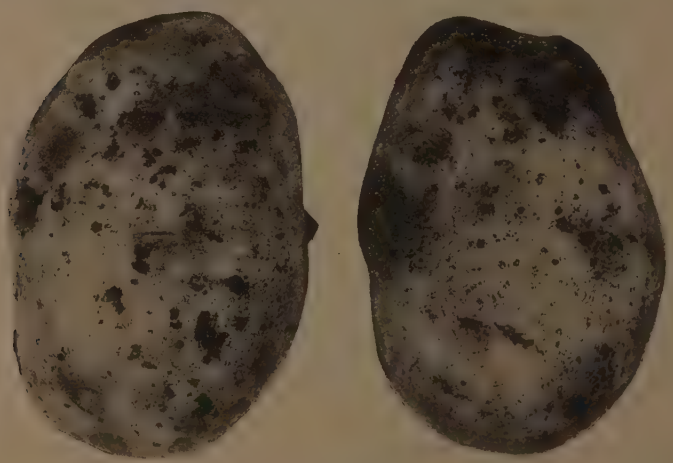


Fig. 11. "Black Scurf."

A severe form of loss comes from the effect of the disease upon plants forming tubers. Affected plants make a rank growth of tops but set a great number of small, misshapen, unmarketable tubers. From 10 to 25 per cent of the plants of a field may be affected. This disease is so serious that the farmer can neither afford to overlook its injuries nor neglect the control measures recommended.

Fig. 12. Effect of "Black Scurf" on the growing sprouts. Note that when the tip rots the plant may start again from below the rotted portion. This leads to a weak, backward hill.

Signs—On the tubers:

Irregular, purple-black lumps, "Black Scurf," about one-sixteenth to one-eighth inch in diameter are formed on the tubers. (Fig. 11.) These look like bits of dirt clinging to the skin, but they do not wash off. When wet, they no longer appear dirt-like, but stand out as black specks on the brown skin of the potato. Sometimes a black, russet-like scab spot is produced when the attack is severe enough to injure the skin.

On the sprouts and stems:

The disease shows upon the young stems as reddish-brown, sunken cankers which may be severe enough to cause a rotting of the sprout. Blank places in the field result from the rotting of the tip of the sprout before it gets above the ground. (Fig. 12.) Weak plants which lag a month or so behind the healthy plants are the result of the rotting off of the shoot and the starting of secondary sprouts from beneath the rotted tip.

Fig. 13. Aerial tubers caused by the girdling of the stems by "Black Scurf."

On the older plants which have been less severely attacked at the early part of the season, cankering and girdling of the underground part of the stem may take place. This girdling severely injures the stem, killing and rotting the bark. Since the food stored in the tuber moves from the leaves in this bark, the girdling interferes with normal tuber formation. This leads to a setting of tubers above the girdled portion and accordingly near the surface of the ground. The tubers thus formed are small and worthless.

Often tubers form above ground in the axils of the leaves. (Fig 13). The girdling effect of the fungus on stolons, also, affects the setting of tubers in cases where the main stems are not so severely attacked.

The cause:

A parasitic fungus called *Rhizoctonia solani* in its pathogenic stage and *Corticium vagum solani* Burt in its fruiting stage is the cause of this disease.

Life history:

Although this fungus, like the scab organism, is now to be found in many soils, the strains vary greatly in virulence. In spite of this occurrence of the fungus in the soil, the chief source of infection to the sprouts is the resting bodies found on the tubers, especially those near the eyes. These resting bodies are merely clumps of fungous threads which carry the fungus over winter. The organism grows out from these clumps in the form of white

Fig. 14. The fruiting stage of the "Black Scurf" fungus.

or slightly brownish threads, which reach the sprouts and bore into them when conditions are favorable for infection. This attack leads to the stem cankers and the rotting of sprouts already described.

In July and August the fungus produces its fruiting bodies about the stems and on the soil about diseased plants. This stage consists of a whitish growth which makes the stem look ashy or mealy. (Fig. 14.) The part the spores thus produced play in the distribution of the fungus and in the production of disease in not known.

With the onset of cool weather the fungus produces its resting bodies on the tubers and this stage plays the most important role in starting the fungus year after year.

Control:

It is clear from the above discussion that the soil and the tubers are the important sources of the fungus and of these the tubers are the more dangerous. The soil may be kept free from serious infestation by the rotation of crops. There is some reason to believe that to follow potatoes with sugar beets, or vice-versa, augments disease. Grain crops and probably clover and alfalfa, are free from the disease.

Early digging of potatoes avoids much of the deposit of black resting-bodies.

Two forms of treatment are available, the one using formaldehyde and the other corrosive sublimate (mercury bichloride) solution.

If formaldehyde is used, the seed stock must be sorted closely to remove every tuber showing black resting bodies, "Black Scurf." An outline for this form of treatment is given on page 43.

If corrosive sublimate is used, it is only necessary to soak the seed tubers for one-half hour in the solution made up at the strength of 1-1000, that is practically, 4 ounces to 30 gallons of water. The solution can be used four times, then should be made up fresh.*

The close sorting required in the formaldehyde treatment is not required with the use of the corrosive sublimate. The reason for this is as follows: Formaldehyde does not kill the threads of the fungus within the lumps and disappearing by evaporation or absorption by the soil, allows the fungus to sprout from within the resting body. On the other hand corrosive sublimate is lasting in its effects upon the resting bodies and exhibits an antiseptic effect preventing the growth of the fungus.

FUSARIUM WILT.

Economic importance:

This disease is found throughout a wide area of the United States. Probably all crops of potatoes grown on sandy land and in a hot growing season are more or less affected. It is particularly serious in Michigan and adjoining states. The losses come chiefly from shortening of the crop due to early death of diseased plants. Many fields show 25 to 50 per cent of affected plants. Total infestation is not unusual. This disease presents one of the most serious of Michigan potato problems for the losses occur every year and in such an insidious manner that they are commonly overlooked.

Signs—The field aspect:

The early death of all the plants or a number of plants occurs long before frost. The dying here and there of hills, commonly ascribed to admixture of early varieties, is usually due to this disease. Sprayed potatoes, free from the Wilt, will stay green, growing and producing a crop, until killed by frost.

*Recent tests by the Department of Agriculture show that the addition of 1 ounce of corrosive sublimate to 30 gallons of the original solution, after dipping each batch of tubers, keeps the solution up to the proper strength.

Upon the growing plant:

In early stages the plant shows rolled or slightly wilted foliage. Frequently the color is of lighter shade. One stalk in a hill or several may be affected. This is followed in the course of a few days by the withering and drying up of affected portions. (Fig. 15.) The woody parts of affected stems are brown when cut across and show a brown stain which is due to the activity of the parasite.

Fig. 15. Plant killed by Fusarium Wilt.

Upon the tubers:

The fungus in the stem gets into the tubers by growing from the mother plant along the tuber stem. The disease is best diagnosed by cutting a thin slice from the butt or stem end of the potato tuber. (Fig. 16.) Invasion of the tubers shows by a yellowing of the vascular ring, which may be evident only a short distance into the tuber—one-fourth inch. In storage, infection is commonly found to have progressed one inch or more into the tubers. The color of the water tubes becomes brown or black as the fungus progresses deeply into the tuber.

Cause of the disease:

A parasitic fungus, *Fusarium oxysporum* Schlect.

Course of the disease:

The fungus probably occurs naturally in all sandy soils. Isolations from Michigan soils which had never grown potatoes yielded the organism. It has been isolated similarly from virgin soils in other states. Evidence points to frequent cropping with potatoes intensifying the infestation by the parasite. Potatoes grown in gardens frequently show a high percentage of Wilt. The fungus is also carried to the field in the seed tuber.

Both sources of infection are important. Primary infection which takes place from the fungus naturally occurring in the soil, doubtless occurs through the fine feeding roots. While sound roots may be attacked it seems likely that the chief infection results from roots wounded or killed by attacks of disease such as Rhizoctonia or Scab, or from the roots near the surface of the soil which are killed by drought, cultivation, etc. Wilting from such a type of infection occurs either late in the season or perhaps not at all. A uniform dying of plants in a field late in the season, accompanied by uniform infestation of tubers can be best explained by the hypothesis that root infection occurred, doubtless in the roots near the surface of the ground which have been killed by the drying of the soil. Tubers from plants so affected show discoloration of the water tube system due to the fungus harbored there.

Fig. 16. The signs of Fusarium Wilt—blackening of the water-tube ring in the butt end of the tuber.

A second type of infection comes about from the planting of tubers with such discolored vascular rings. The fungus in the seed piece readily grows into the sprout and produces its effects early in the season. This leads to the severest form of the trouble and in it the plants wilt and die when the tubers are only half grown. Tubers from such wilted plants are commonly about the size of a hen's egg and have pointed ends. They also harbor the Fusarium fungus. The planting of small, whole potatoes directly from the bin serves to load the seed stock with the diseases such as this one which lead to the production of small potatoes. If small potatoes are to be planted, it must be known that they are from vigorous hills.

In either type of infection, the fungus invades the water tubes of the plant and lives there and gives off its poisonous by-products. Wilting probably comes about from poisoning of the plant rather than actual stoppage of water supply.

The fungus grows into the tubers from the affected stems. Immature plants frequently show some tubers into which the fungus has not yet grown.

The fungus has not been known to fruit in or upon the growing plant in the field. It doubtless fruits in the soil.

Control:

Any set of control measures must recognize the two sources of infection. Ultimate control can only come from varieties resistant to the disease. These, as yet, have not been developed. The control measures suggested will do much to cut down loss.

Avoid unnecessary wounding of the roots of growing plants.

Rotation of crops prevents loading the soil with the parasite.

Infected tubers should be stored under dry, cold conditions to prevent rotting in storage and to prevent excessive advance of the fungus into the tubers.

Since the most serious effects come from planting tubers harboring the fungus, it is necessary to attempt to rid the tuber of this infestation. Since the fungus lives in the butt-end of the potatoes, this can best be done by consistent rejection of all butt-end pieces. Tubers for planting should be cut by hand after the usual disinfection. The first cut should remove one-half to one inch of the butt or stem end. This should be rejected. If the tuber so cut shows no flesh discolorations then cut for seed in the usual manner; if the flesh is stained or discolored, reject the whole tuber. This method practically frees a seed stock from the infestation which leads to the severe forms of Wilt.

BLACK LEG.

Economic importance:

This disease is wide-spread in the Upper Peninsula. Before the summer of 1917, it had been reported, in a few localities, from the Lower Peninsula, and then chiefly in potatoes imported from northern localities. The disease was known to cause 25 to 75 per cent loss in certain fields in 1915. In the wholesale shipping of tubers into the state which took place in the spring of 1917 to supply seed stock, Black Leg was introduced into a great number of southern counties. It is the cause of serious rotting of tubers in storage. Black Leg is a dangerous, unnecessary disease.

Signs—On the young plants:

This disease manifests itself by rotting the stem, which softens and turns coal black. The rotting usually extends from tuber to surface of ground and may blacken upper parts of stem. Young and old plants are attacked. Stems of old plants become hollow through rotting of the pith. In wet weather the stems become soft and slippery. (Fig. 17).

The leaves become a bright yellow and roll. As the cutting off of the water supply takes place, the leaves wilt and die.

On the tubers:

Tubers rot, usually from stem-end inward, with a black rot, in which, commonly, canals or rotted pits lined with a creamy bacterial slime, occur. (Fig. 18).

Cause:

A bacterial organism, *Bacillus atrosepticus* Van Hall.

The course of the disease:

The germs are carried to the field in tubers which grew on plants in which Black Leg disease developed but lightly or late in the season. Bruised or wounded tubers are also believed to harbor the germs. Affected tubers, when planted, rot in the ground and communicate the disease to the sprouts. The Black Leg germ, with favorable soil conditions, may kill the young

Fig. 17. Black Leg on a young plant.

plant before the end of the first month, or, the disease may progress very slowly. The disease has been observed to spread widely in a field during a wet season. How the causal organism is carried from plant to plant is not known, but it may be that the insects which infest rotted tissue or the washing of water from plant to plant are the agencies. Cultivation may be a means. Slightly affected plants or those in which the disease develops late in the season show tubers with the vascular system discolored and sometimes soft rotted. The germs pass from crop to crop in such tubers and also in

those wounded or bruised tubers inoculated by contact with infectious matter in the soil or store house.

Control:

It is not known for Michigan conditions whether the germs live over winter in soil which has borne a diseased crop. The rotation which is necessary for other reasons will eliminate all danger from this score.

Sound seed tubers, free from rot, wounds, bruises, scab, or other blemish, disinfected in either formaldehyde or corrosive sublimate, will give a crop

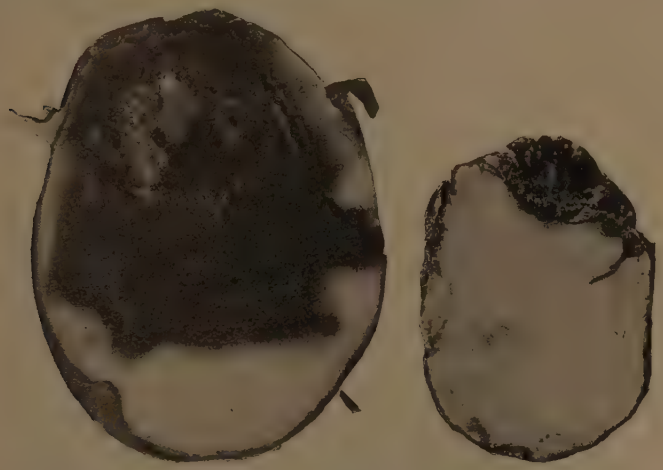


Fig. 18. Tubers rotted by Black Leg bacteria. Note blackening and tendency toward canal formation. The glistening mass is the slimy bacterial growth.

practically free from Black Leg. In the season of 1915, observations which were made in the Upper Peninsula showed that seed tubers carefully sorted and treated, gave less than one-tenth of one per cent of Black Leg. Seed tubers from the same car, planted without care gave a field with 75 per cent Black Leg.

Black Leg plants (including such tubers as are formed) wherever found in the field, should be carefully pulled, carried from the field and destroyed. This keeps the diseased tubers out of the seed stock.

DISEASES CONTROLLED BY SELECTION OF SEED STOCK FROM HIGH-YIELDING HILLS.

CURLY DWARF.

Like Leaf Roll, this disease is a sort of "running out" of certain lots of seed tubers. As high as 10 per cent of the hills in commercial fields have been known to show the disease. The disease is transmitted in the tubers and becomes worse with each planting of the diseased seed stock.

Signs:

Affected plants show down-curled leaves whose leaflets give a shirred or ruffled appearance to the plant. The stems are much shortened and the plants dwarfed. The tubers are small. (Fig. 19).

Fig. 19. Curly Dwarf as contrasted with a healthy plant.

Cause:

The cause of this trouble is unknown. The disease is not yet proved to be infectious. By some, the disease is considered due to a deterioration of the seed stock or as a running out or degeneration of a variety.

The grower first notices a weak hill, dwarfed and slow growing. Tubers from such hills produce a progeny still more diseased. Eventually the tubers produced are too small to be harvested and the disease is automatically

checked. Early frosts or severe droughts probably do much to eliminate such weakening diseases from the field, since growth is checked before tuber formation has proceeded very far.

Control:

See Leaf Roll.

WITCHES' BROOM. (SPINDLING SPROUT?).

In a certain lot of seed a peculiar degeneration of the plant has developed repeatedly in the last four years. In this trouble the number of shoots arising from the seed piece has increased enormously, as many as a hundred fine, wiry sprouts developing from the main outgrowths. (Fig. 20.) The

Fig. 20. Witches' Broom of the potato.

leaves on such shoots remain small. The plant, in severe cases, forms a dense mat, losing all resemblance to the normal potato plant and appearing like a mat of chickweed. Small tubers, sometimes no larger than a peanut, are produced. The disease would thus quickly be eliminated from the seed stock when care in seed selection is taken.

A disease which leads to excessive bud development and bud growth produces what is called a Witches' Broom. These are known for many

plants, but the fundamental cause which releases the forces of the plant has not been discovered. This potato disease seems of the same general type of trouble. As yet, it is merely a curiosity and has assumed no commercial importance.

LEAF ROLL.

As has been said for Curly Dwarf, this disease is a sort of degeneration of the potato plant. One variety may show a striking amount of the disease. Fields showing 50 to 100 per cent Leaf Roll have been reported. One variety grown at the College showed every plant in the row diseased. Failure of the crop in certain noted potato-producing sections has been attributed to Leaf Roll.

This is the least understood of all potato diseases and considered by experts to be potentially the most serious menace to the industry.

Fig. 21. Leaf Roll. The curling of the leaves is permanent irrespective of soil moisture.

Signs—On the leaves:

There are usually shown permanently rolled (that is not unrolling with wet weather, etc.), leaflets, usually light, greenish-yellow, which in typical cases may be bronzed or reddened. (Fig. 21.) The leaflets of the lower leaves are most characteristic. These, particularly the terminal one, take on a spoon-shaped appearance due to the upturning of the tips. They have a peculiar nature and crackle and rustle when brushed against. When bent, they break with a very audible snap, indicating their brittleness. Such leaves may show a great number of black dots scattered over the leaflets, or they may be bronzed or they may, in some cases, remain nearly normal. Leaves from leaf roll plants do not wilt so readily as healthy leaves.

General appearance:

In severe cases the affected plants are sharply set off from the healthy broad-leaved, deep-green plants. The furled leaflets are sometimes found in both young and old leaves, the unhealthy color and the dwarfing in the last stages are characteristic.

On the tubers:

The tubers borne on diseased plants are frequently set close to the stems, although seasonal effects are also known to produce similar close setting with some varieties. The seed piece is often found firm and crisp, even at digging time. The tubers on diseased plants are small and what was said about planting small tubers indiscriminately from the pit or cellar, under "Fusarium Wilt" applies with particular force here.

The cause of the disease:

As in Curly Dwarf, the cause of this potato disease is unknown. One investigator claims to have proved that the disease is infectious and caused by a virus which infects the growing plants and which is carried year after year in the seed. Attempts made in this country to show the spread of the disease from plant to plant are so far without results. Two suggestions concerning the disease are commonly made in this country, namely, that the disease is due to a degeneration of a variety, "running out," and second that the leaf roll is the "holdover" effect of improper growing conditions upon the tubers the preceding season.

The control:

Without definite knowledge of the cause of the diseases of this type it is evident that control measures to be proposed must be of a general nature. It is advisable that farmers learn to recognize these deviations from the normal, healthy standards and that they make strong effort to eradicate such diseased plants from the fields to be used for a source of seed stock.

Whether the farmer actually learns to recognize each particular type of disorder is not important, but it is important that he see the danger from weak hills. In addition, it is important that, in general, seed stock be procured from high-yielding hills. This means that the farmer should set aside the best portion of his field as a seed plot and go over this field several times during the summer, pulling out all weak hills and getting rid of all plants of the undesired varieties. Then the plants should be dug by hand and only those hills saved for seed that show a high yield and proper type.

With such seed the yield can be raised from a mediocre, unprofitable one to a bumper crop, in which the danger of "running out" of seed is absent.

MOSAIC.

Green Mountain potatoes and some other varieties frequently show peculiar down-turned leaflets in which the veins stand out prominently. (Fig. 22.) Such leaflets are mottled with patches of light green, giving rise

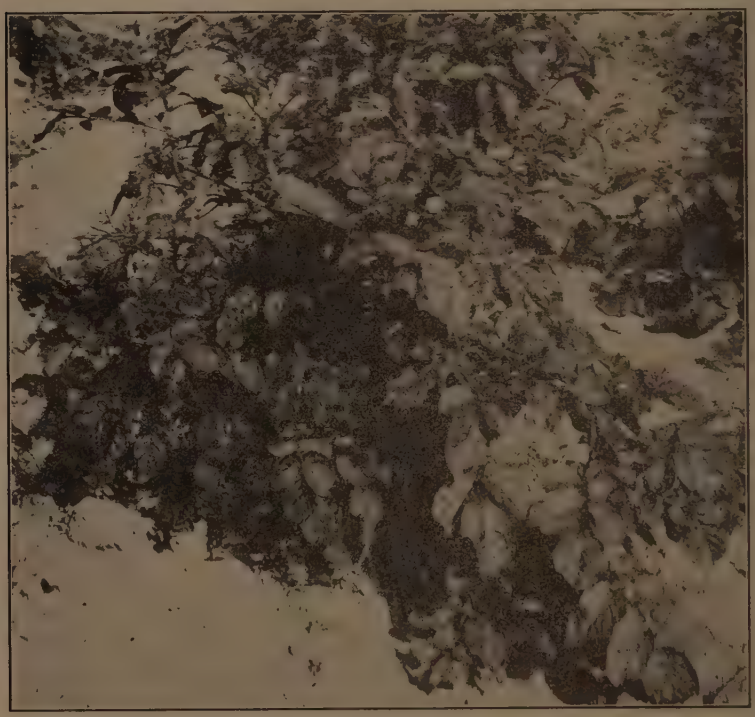


Fig. 22. Potato Mosaic.

to the name applied to this malady. Observations made in 1915 seemed to indicate the disease is infectious, probably transmitted by aphids. It is certain that tubers from affected hills reproduce the disease the next year. The disease is known to reduce the yields of fields strongly, some affected fields yielding only 70 or 80 bushels in years when healthy fields under the same conditions yielded 200 bushels. The farmer must recognize this disease in order to avoid using tubers from affected hills for seed purposes. Mosaic plants occurring here and there in a field should be pulled out and destroyed in order that they may not be a source of infection. Aphid control is important.

OTHER DISEASES OF THE POTATO.

FUSARIUM DRY ROTS.

Sometimes in years when Late Blight is not a factor, dry rotting of the tuber occurs. (Fig. 23.) This puzzles the farmer who is not always able to distinguish between the various kinds of rotting which occur on the potato. Late Blight Rot is commonly seen at digging time or immediately after the tubers are put in the storage cellar. Beginning then, it develops throughout

Fig. 23. Dry Rot caused by Fusarium.

the storage period. The Fusarium Rots, on the other hand, under Michigan conditions, do their greatest damage during the latter part of the storage period, and are associated with warm, humid storage conditions and with bruising or wounding of the tubers. Tubers dug when so immature that the skins break easily, suffer loss from the Fusarium Dry Rot. The great loss which occurs in the "new" potatoes shipped in from the South, comes about from this sort of trouble.

The rot produced is at the outset firm and cheesy, unless the tuber has been under very moist conditions. The causal fungus often fruits upon the surface of the rotted portion, producing white or pinkish tufts of mold. Eventually the tuber shrivels and dries to a hard mass. When partially rotted tubers are used for planting, the seed pieces are apt to rot in the ground before the sprout is established.

The cause and control of the disease:

This disease of the potato arises from the attack upon the tuber by various fungi of the Fusarium genus—a group of organisms widely distributed in soils and found naturally on the potato tuber. Under ordinary conditions the tuber remains free from the trouble, but if the skin be broken, if the tuber be wounded, or if the Fusarium Wilt fungus has penetrated deeply, rotting is apt to take place providing that storage conditions are favorable for the growth of the rot organism.

The necessary control measures are clear from the above statement. If tubers are dug after the skins have become tough and if better care is used in handling, the bulk of this loss can be eliminated. In the various farm operations, in loading potatoes into cars and in running the potatoes into cellars with chutes, etc., the danger from bruising the skin of the potato must be recognized, if the loss from this cause is to be avoided. The time will come when potatoes will be handled as carefully as apples.

ROT CAUSED BY HONEY MUSHROOM, *Armillaria mellea.*

Sometimes when potatoes are planted on newly cleared land, hills near stumps are found showing rotted tubers. This arises from the attack of a parasitic mushroom which has been rotting the roots of the forest tree and

Fig. 24. Rot caused by the Honey Mushroom. The thread-like bodies are the fungous growths.

whose threads have met with the potato tuber. The Honey Mushroom injury can be recognized by the string or root-like masses these fungous threads form. (Fig. 24.) The mushroom itself seldom develops in the summer, although it can be found in the fall about the bases of stumps.

The rot caused is more of a curiosity than a serious loss and need not deter anyone for utilizing newly cleared or partially stumped land for potatoes.

HOLLOW HEART.

In years of abundant rainfall when large potatoes occur commonly in the hills, many of these show clefts at the heart. (Fig. 25.) In these the flesh

Fig. 25. Hollow Heart.

splits leaving a lens-shaped hole. The lining of this cavity becomes brown, just as the cut flesh of a potato turns brown when exposed to the air.

It would seem that a heavy rain at the time when tubers are forming leads to a sudden surge of growth and the splitting results from unequal growth of the parts of the tuber.

Certain varieties more than others tend to the production of extra large tubers. Since such tubers are in disfavor with the trade, and under the government grades are not considered sound potatoes, it is necessary with such varieties to plant closer in order that by slight crowding this tendency to produce large tubers can be overcome. It is evident also that the evening up of moisture supply which comes from good drainage and from frequent cultivation will have a beneficial effect in preventing this trouble.

INTERNAL BROWN SPOT.

During drought years potatoes show rusty flecks throughout the flesh. (Fig. 26.) This is not caused by a parasite, but seems wholly a reaction to

some unfavorable growth condition. Such tubers when planted do not transmit the disease, but it is doubtful if it is advisable to use them for seed purposes. As is advised on page 36 the farmer should reject for seed purposes all tubers showing discoloration of the flesh.

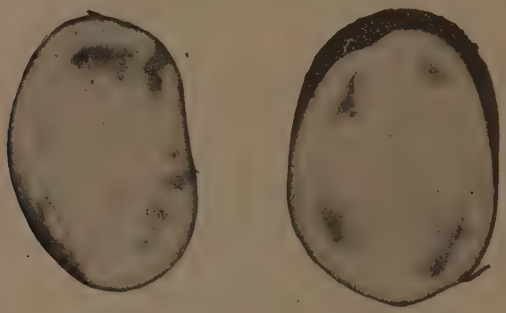


Fig. 26. Internal Brown Spot. The flecks are rusty and are found throughout the flesh.

"NO-TOP" POTATOES.

As was seen under the discussion of Leaf Roll, there is some reason for believing that unfavorable soil conditions during time of tuber formation is reflected in the crop produced by such tubers. In the spring of 1917, many

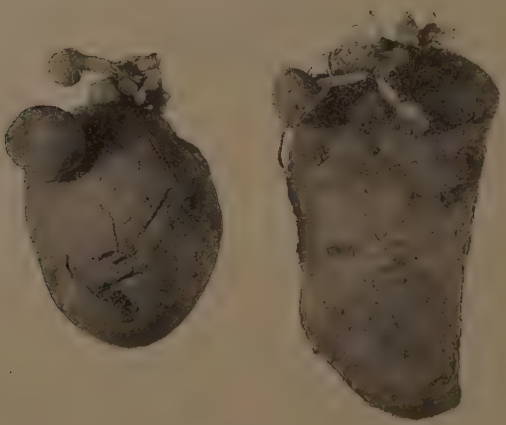


Fig. 27. Seed tubers which produced small tubers but no sprouts.

tubers grown during the drought of 1916 produced a few little tubers from the seed piece, but no sprouts at all. (Fig. 27.) Whole fields showed this phenomenon. No one as yet has determined the underlying cause for this

behavior, but the lesson is clear—seed stock should come from fields and from hills above suspicion.

FROST INJURY TO POTATO TUBERS.

When potatoes freeze in the ground, they often show rotting of the frozen portions which resembles in part the various rots of the tubers previously described. Such injuries must be carefully distinguished. It sometimes happens that the tubers, when loaded, show only the shrinking and wizening which comes from freezing and they rot later in the course of shipment. (Fig. 28.) Such cases of "Field Frost" may readily be distinguished from

Fig. 28. The end of this potato was frozen and rotted. The white masses are fungous tufts which developed as a result of the rotting.

injury received in transit through position of the potatoes in the car, etc. Field frost will be distributed throughout the car, while freezing in transit occurs at the more exposed portions.

Another form of injury which comes from exposure to cold, especially from prolonged chilling at temperatures near the freezing point, shows as blackening of the fibrils of the potato, especially at the stem end. (Fig. 29.) This blackening resembles the disease described as Net Necrosis,* which is found in the field before frost occurs. The type induced by chilling may be provisionally called Frost Necrosis. Usually with this form of injury the tissue shrinks slightly, indicating clearly the relation to the chilling. In other

*Net Necrosis was described a few years ago as a disease found early in the fields, where freezing was not a factor, in which the tubers showed blackened fibrils all through the flesh. (Fig. 30.) Sections through the tuber at almost any part showed the diseased condition, although it is more evident at the stem end. The blackened flesh is free from parasitic organisms and the disease is believed to be of some such nature as Mosaic or Leaf Roll.

cases, the netting of the tuber is the only sign and this is evident only upon cutting. With Net Necrosis, the netting extends to the center of the tuber or beyond, while with Frost Necrosis, the injury is local. Lightly frosted tubers often show brown or grayish-black areas in the flesh at the stem end,

Fig. 29. Frost Necrosis, due to chilling in the field.

just outside the vascular system and under the skin about an eighth of an inch. (Fig. 31.) The flesh is somewhat withered at these places. Such tubers blacken when cooked. The physiological basis of this condition has not, as yet, been fully worked out.

Fig. 30. Net Necrosis. All the fibres of the tuber from stem end to tip were blackened.

Fig. 31. Blackening of the flesh as a result of chilling.

BLACK HEART.

Potatoes shipped during the winter when cars have to be heated with stoves sometimes arrive at the market with the tubers near the stove showing an inky black heart. (Fig. 32.) Experiments have shown that tubers heated to 100° F. will develop this trouble, thus fastening the cause on the over-heating which occurs near the stove. It has also been found that this blackening of the heart can take place at much lower temperatures if the air supply about the tubers is limited.

Occasional losses of this sort have been reported from large pits, and to avoid loss it is advisable that care be taken to provide good ventilation in

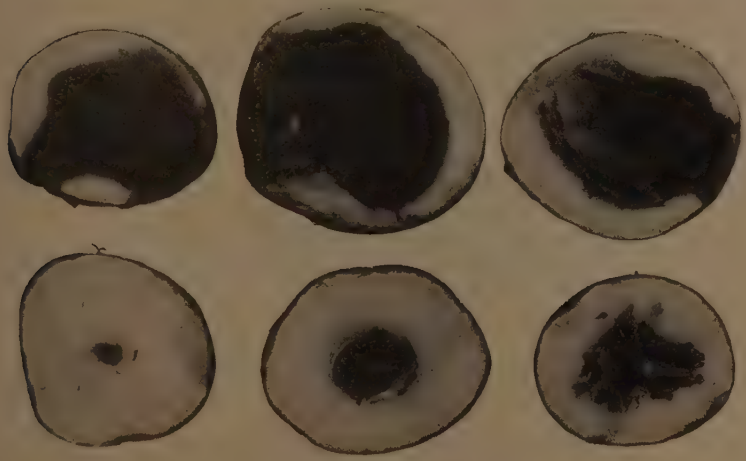


Fig. 32. Black Heart of potato.

large pits or other storehouses. The use of refrigerator cars for potatoes should be resorted to early in the shipping season rather than the shipper taking chances with lined, stove-heated cars during severe freezing weather.

LIGHTNING INJURY TO FIELDS.

In 1917 the attention of the department was called to what seemed to be a very infectious disease which was destroying the potato plants in a field in ever widening circles. When first discovered the plants were withering away in a small area about five feet in diameter. The stalks were brown and dead, but the leaves remained green. Eventually the plants with the brown stems fell over. Each day the area was seen to enlarge.

The trouble just described was caused by a stroke of lightning. The same type of trouble is known to occur on a number of different plants. In seasons when electrical disturbances are numerous, the cases may be considerable in number. Last year three were brought to the attention of the College. The size of the affected area varied considerably, but in the largest seen, the diameter was 35 feet. In this case the plants were killed in an almost perfectly circular area. The potatoes in this case were not ridged. In the lightning injury illustrated, the affected plants are seen to extend along the ridges outside of what would make up a perfect circle. (Fig. 33.) Perhaps this is associated with water standing in the furrows between the ridges.

The progressive dying of the plants in widening circles may continue for several days after the spot is first noticed and seems to be associated with the varying severity of the effect on the plants subjected to the shock, those nearest the place where the lightning struck being most severely injured.

There is no potato disease of such infectious nature as to render it likely that confusion would arise over this peculiar field symptom. The trouble loses its seemingly infectious character after about a week and the farmer has a bare spot in his field surrounded by healthy plants. The matter should be understood by farmers so that undue alarm need not be felt when such injury occurs in the field.

Fig. 33. Lightning injury to potato.

PROGRAM FOR THE CONTROL OF POTATO DISEASES.

FIRST—SELECTION OF SEED STOCK.

Control of potato diseases consists in the main of removal of diseased plants, selection of strong plants, rotation of crops, seed treatment, and spraying. The following outline suggests a method for development of a seed stock on any farm which will be safe seed for safe soil.

Decide on variety fitted for your locality and market.

Learn the characteristics of the vines of this variety and of the tubers.

Inspect a quarter acre or more seed plot at blossoming time and pull out or stake all "off varieties." The College through the extension department maintains a service to help farmers make a start in this seed selection. Get in touch with the College (through your County Agent) and start with a uniform, high-yielding seed stock. (Fig. 34).

Fig. 34. Typical Extension School in the potato field.

Pull out and destroy all weak, diseased hills. This treatment is aimed especially at Black Leg, Leaf Roll and Curly Dwarf. Learn to know potato diseases as shown on the vine. Here again, the extension service of the College will help to teach you how to clean up your seed stock.

Dig the hills of the seed plot by hand. Do not trust this important measure to unskilled, hired help.

Select high-yielding hills of proper type of the chosen variety for an "extra select" seed plot.*

*For real potato breeding work these hills should be put in separate sacks and planted as tuber-unit hills, preferably keeping all tubers of one hill distinct from the other hills. Interesting results come from tuber units of healthy vigorous hills. Merely quarter the treated tubers as you plant and leave a space between each four. A weak, diseased tuber will usually produce four spindling plants, and can readily be detected. A strong tuber produces strong, vigorous plants.

SECOND—SEED TREATMENT.

Select only sound, desirable tubers for treatment. Scabby, bruised, or partially rotted tubers are unsafe.

Treat seed in either of the following ways:

A. Corrosive sublimate treatment.

Soak the seed tubers in corrosive sublimate solution for one-half hour. The solution is made with 4 ounces of Corrosive Sublimate in 30 gallons of water. This treatment controls Scab and Black Scurf. Reinfection from untreated sacks must be avoided. Disinfect these containers in the treating solution.

Points on the treatment:

Corrosive sublimate crystals or the diluted solution are deadly poisonous. Use precaution and keep this material out of the way of live stock or children.

The crystals dissolve slowly in cold water, but rapidly in hot water.

Treated tubers are not safe to feed to stock.

Corrosive sublimate, as the name indicates, attacks metals. It must be used in *wooden* vessels.

Potatoes should be uncut when soaked.

Treatment with small lots can be readily given by use of a barrel, soaking one sack at a time. (Fig. 35).

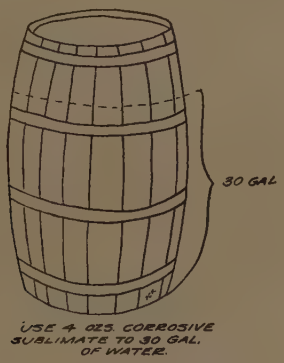


Fig. 35. Diagram illustrating use of barrel for treating small lots of potato seed.

Larger quantities can most readily be handled in a large vat made of heavy stuff, holding 8 to 12 crates at a time. It is well to make this vat water tight by use of heavy duck lining, painted with some water-proof paint, such as asphaltum. (Fig. 36).

The solution can be used 4 times. It loses strength due to the potatoes taking out more of the chemical than they do of the water. After the fourth batch is treated, make up fresh.

The addition of one ounce of corrosive sublimate to 30 gallons of solution after each batch is dipped, keeps the treating solution at the proper strength.

Experiments completed in 1917 show that treatment for one-half hour is as efficient as the longer soaking, (1½ to 2 hours) previously advised.

B. Formaldehyde treatment.

If the farmer knows the signs of Black Scurf on the tubers and if he

will consistently reject *all* tubers showing the purple-black masses when cutting, the old Formaldehyde treatment, known for a long time for use against Scab, may safely be employed.

Soak the uncut potatoes for 15 minutes in Formaldehyde solution made with one pint of concentrated Formaldehyde (36 to 40 per cent) in 30 gallons of water.

Points on this treatment:

The experiments completed in 1917 have shown that 15 minutes is as effective a period as the longer time, (1½ or 2 hours) previously recommended.

This solution does not have the power to prevent the "Black Scurf" from causing infection after the tubers are planted, hence the necessity of close sorting when cutting. Since the "Black Scurfs" are very evident when the tubers are wet, if the cutting is done immediately after treating, this sorting is an easy matter.

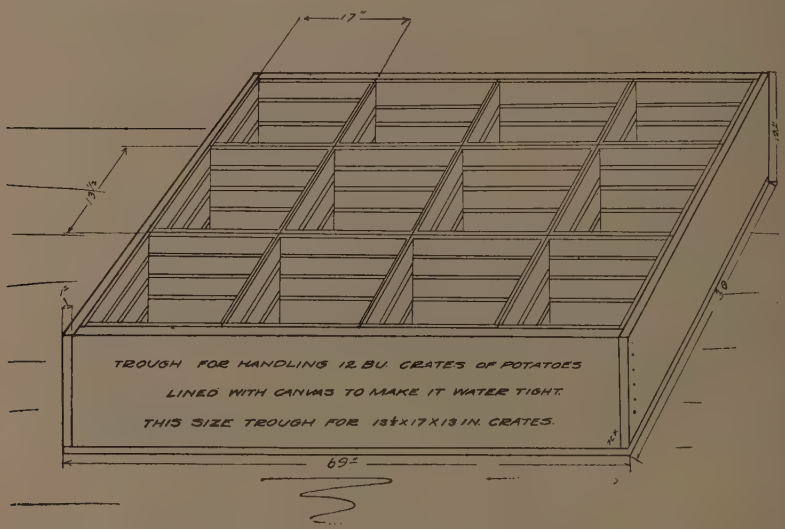


Fig. 36. Diagram illustrating large vat for use in treating large quantities of potatoes.

The weak formaldehyde solution does not lose strength on standing as is commonly supposed, but it gets slightly stronger. Unlike the corrosive sublimate, it may be used repeatedly for treating.

It is very probable that treated potatoes are not desirable stock food, even when cooked, because of the very injurious effects of even slight amounts of formaldehyde upon digestive processes.

This treatment is about one-third cheaper than the corrosive sublimate treatment.

Formaldehyde is a strong chemical. It is not safe to vary the strengths from those given. Measurement of water may be approximate, the farmer bearing in mind that a large barrel holds 50 gallons. For smaller lots, a large pail, holding 3 gallons, may be used for measuring.

THIRD—RIGID INSPECTION AND SORTING OF THE SEED-TUBERS WHEN CUTTING.

(a). Cut the seed by hand. Here is the best place to better a seed stock. Do not leave this totally to hired help. Be on the job and teach the cutters to use only safe seed stock.

(b). Cut off and throw away a slice one-half to one inch thick from the butt end of each potato. If the water tubes show up as a dark ring, discard the tuber. Any blackening of the flesh is suspicious.

(c). Reject any rotted, scabby, bruised or wounded seed stock. Cases of Rhizoctonia should be thrown out. If the potatoes have been treated with corrosive sublimate or formaldehyde the rejected potatoes or parts are not safe for stock feeding.

(d). Plant at once. If this is impossible, take care that the potatoes do not heat or decay before planting.

FOURTH—GIVE THE POTATO PLANT GOOD CULTURE.

Plant the potatoes on enriched ground—clover or alfalfa sod is best. Have at least a four-year rotation system. The soil must be well drained. Potatoes do well upon and improve slightly acid soil. Give them the best of care. Any set of treatments fails with neglected plants.

FIFTH—CONTROL LEAF DISEASES.

Spray the plants thoroughly with home-made Bordeaux Mixture, 4-4-50 beginning when the plants are 8 to 10 inches tall, making 4 or 5 applications at intervals of 10 days or two weeks.

Use freshly prepared Bordeaux Mixture prepared as directed on page 48.

Lime Sulphur is worthless for potatoes. Commercial Bordeaux mixtures have never proved satisfactory. For equivalent strengths of copper they cost about four times more than home-made mixtures. Their cheapness is only fancied and comes about from the low percentage of copper that they carry.

Control "bugs" by rotation, late planting and by arsenical sprays. Add one-half lb. of Paris Green or 3 lbs. of Lead Arsenate paste, or better, 2 quarts of Kedzie mixture to 50 gallons of water or to 50 gallons of Bordeaux mixture as the case may be. Paris Green is made safer by the addition of lime, pound for pound, when water alone is used.

If the month of July is cold and wet, Late Blight is almost sure to do damage on the late crop. Spray applications should be increased when such dangerous weather conditions prevail.

Read carefully the discussion of the type of sprayer and the methods of applying spray mixtures.

THE SPRAYER AND HOW TO APPLY THE SPRAY.

Any sprayer is better than none, but a sprayer that gives a high pressure and a fine mist which can penetrate well under the leaves is most efficient. Crops have been saved with a knapsack sprayer in times when Late Blight was imminent, or even by timely applications of home-made Bordeaux mixture put on with crude brooms made of hay or brush.

Careful, thorough spraying as a regular part of the potato-growing program always pays. (Fig. 37.) An adjustment of the nozzles to deliver the spray upward is preferable to the common practice of using one nozzle above the center of a row. New discs should replace old, corroded ones in order to economize spray mixture.

We advise every farmer to make a home-made arrangement for the nozzles as is shown in the cut. (Fig. 38.) The form shown was made at the expense of $2.00 for use with a hand power barrel pump. It covers two rows at a time. The same device can be enlarged to handle four rows for use with larger machines. (Fig. 39).

Experiments have shown that thoroughness in applications brings the results.

Fig. 37. Unsprayed strip in a Kalamazoo field. Summer of 1915. (Photo by C. W. Waid)

Fig. 38. Home made attachment for arranging nozzles to shoot the spray upward. Device fixed for use with a barrel pump. For larger sprayers more rows could be provided for.

Fig. 39. Another simple home-made attachment for arranging nozzles to deliver spray upward. (Photograph through courtesy of James Redpath.)

THE MAKING OF BORDEAUX.

FOR SMALL ACREAGES.

(1) Saw a 50-gallon barrel (vinegar or oil) and make two 25-gallon tubs.

(2) Put 2 pounds of Bluestone (called Blue Vitriol or copper sulphate) in a cloth sack and hang over night in one-half tub of water (12½ gallons). Bluestone dissolves slowly. Hang it the night before so that the sack is just under the surface of the water.

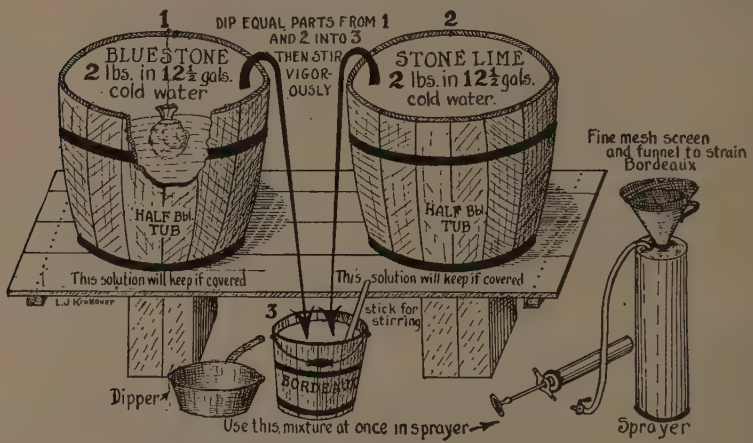


Fig. 40. Making Bordeaux Mixture for small acreages.

(3) Make a lime paste by slaking 2 pound of fresh stone lime in one-half pail of water. Stir this into the half tub (12½ gallons) of cold water. Hydrated lime (comes in sacks) may be used. Use 2½ to 3 pounds of hydrated. Then follow the directions in the picture. This method will make 25 gallons of spray.

FOR LARGE ACREAGES.

To make 100 gallon batches:

Bordeaux 4-4-50 or 8-8-100 formula.

(1) Secure four 50-gallon barrels.

(2) Fill barrel No. 1 half-full, and hang 25 pounds of Bluestone so that the Bluestone is just under the surface of the water. This makes stock Bluestone, 1 pound to the gallon.

(3) Fill barrel No. 4 half-full of water and stir 25 pounds of freshly slaked stone lime or about 30 pounds hydrated lime in it. This is the stock lime paste, about 1 pound to the gallon.

The stock solutions will make 300 gallons of spray. They will keep if covered.

(4) Take 8 gallons stock Bluestone from barrel No. 1 and add 42 gallons of water in barrel No. 3. (That is, fill the barrel).

(5) Take 8 gallons of stock lime from barrel No. 4 and add to 42 gallons of water in barrel No. 3.

(6) Run these materials together through a strainer into the sprayer tank. The combination is Bordeaux mixture and must be applied at once.

If the spray tank holds only 50 gallons make the dilution on one-half the above scale.

The first batch may be tested with litmus paper to make sure that there is lime enough. If blue litmus paper turns red, add more lime. *With good fresh lime using the amounts given, no test is needed.* If weather conditions prevent the using of a batch of Bordeaux, it may be kept for a long time if cane sugar is added at the rate of one-half pound to 50 gallons.

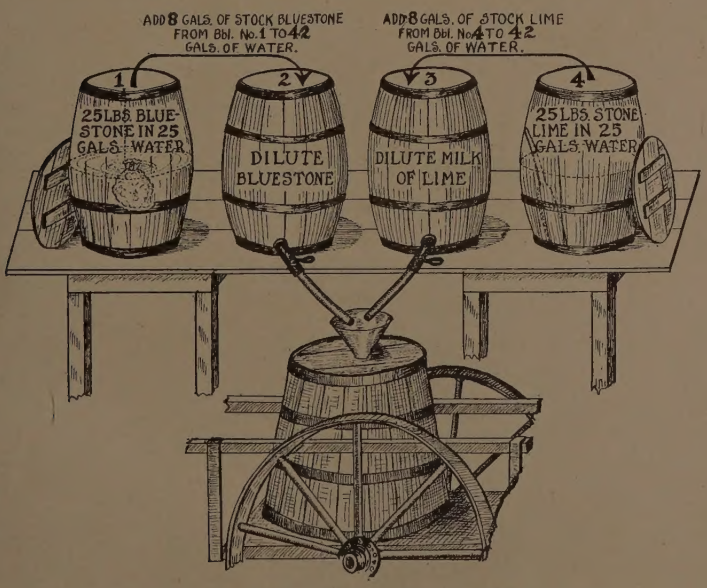


Fig. 41. Making Bordeaux Mixture for large acreages.